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Research Article

# INFLUENCE OF ALTERNATE WETTING AND DRYING IRRIGATION REGIMES AND NITROGEN MANAGEMENT PRACTICES ON GROWTH AND YIELD ATTRIBUTING CHARACTERS OF RICE

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**Abstract-** A field study was conducted to investigate the effect of different alternate wetting and drying irrigation regimes to nitrogen management practices on the growth attributes, yield attributes and yield of Rice. The experiment was laid out in a split –plot design with three replications. Main plots were assigned with five irrigation regimes as *i.e.,* I1- Conventional practice of Irrigation (CI) (5 cm depth of irrigation one day after the disappearance of previously ponded water), I2, I3, I4- i.e., AWDI at 10, 15 and 20 cm drop of below surface water using monitoring device field tube and I5- SRI irrigation practice (2.5 cm depth of irrigation and reirrigation given after the formation of hair line cracks). The sub plots were experimented with nitrogen management practices *viz*., N1-two equal split application of 100 % RDN at basal and Panicle Initiation (PI) stages, N2- four equal split application of 100 % RDN at basal, Active Tillering (AT), PI and heading stages, N3- three equal split application of 75 % RDN at AT, PI and heading stages and N4- LCC based N application. Among the irrigation regimes SRI method of irrigation practice on bar with AWDI at 10 cm and CI recorded higher growth attributing characters *viz.,* Plant height, Root length, LAI, Dry Matter production, total tillers $m^{-2}$ and yield attributing characters *viz*., panicles $m^{-2}$, panicle length, number of grains $panicle^{-1}$, ill-filled grains percentage, grain and straw yield. The nitrogen management practices also strong influence on the growth and yield. The four equal split application of 100 % RDN fertilizer at basal, AT, PI and heading stages and LCC based N application to be the better managements among the nitrogen management treatments. And also the higher water use efficiency was recorded in AWDI at 15 cm drop of water table it because of the maintenance of optimum level of yield.

**Keywords**- Irrigation regimes, Field tube, Alternate Wetting and Drying, Nitrogen Management.

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## Introduction

Rice is the dominant staple food crop of the world's 2.7 billion people and is critically important for the global food security. In the World, rice production is 476 million tonnes, with India producing 105 million tonnes of rice, in an area of 44 million hectares [1]. Geometric growth of population and arithmetic increase in food grain production in this century is expected to double the food production to short out the food demand. Over the decades declining water availability and quality as well as increasing demand for fresh water had hover the sustainability of rice production in the world [2].

To overcome this problem and increase the rice grain production to meet the food security we need to develop novel technologies that will sustain or enhance the rice production by increasing irrigation efficiencies. If rice is grown under traditional conditions, farmers resort to continuous submergence irrigation resulting in enormous wastage of water and lower water use efficiency. Hence it becomes essential to develop and adopt strategies and practices for more efficient use of water in rice cultivation. Such a way for increasing water use efficiency in rice irrigation is the Alternate Wetting and Drying Irrigation (AWDI) *viz*., irrigation to particular depth after disappearance of previously ponded water in which rice fields are not kept continuously submerged, but are allowed to dry intermittently during rice growing stages.

The intermittent drying periods may alter the uptake efficiencies of nutrients. The efficient nitrogen management especially its time of application and number of splits has an influence on enhancing the yield of rice. Through split application of nitrogen and the LCC based N application can made nitrogen available to rice continuously. Though this experiment was formulated to study the effect of different irrigation regimes with nitrogen management practices on growth and yield of rice.

## Materials and Methods

The field experiment was conducted at Central farm complex of Agricultural College and Research Institute, Killikulam during *Rabi,* 2012 with the variety of ADT (R) 47. The farm is geographically situated in the southern part of Tamil Nadu at 8°46' N latitude and 77°42' E longitude at an altitude of 40 m above mean sea level. The soil of the experimental site was sandy clay loam, pH 7.1 with medium available organic carbon (0.52 %), low available N (247 kg $ha^{-1}$), medium available $P_2O_5$ (42 kg $ha^{-1}$) and medium available $K_2O$ (242 kg $ha^{-1}$).Irrigation management practices were assigned to the main plots in split plot design with three replications *viz.,* Conventional practice of Irrigation (CI) (5 cm depth of irrigation one day after the disappearance of previously ponded water), AWDI at 10, 15 and 20 cm drop of below surface water using monitoring device field tube and SRI irrigation practice (2.5 cm depth of irrigation and reirrigation given after the formation of hair line cracks). The sub plots experimented with nitrogen

management practices *viz*., two equal split application of 100 % RDN at basal and Panicle Initiation (PI) stages, four equal split application of 100 % RDN at basal, Active Tillering (AT), PI and heading stages, three equal split application of 75 % RDN at AT, PI and heading stages and LCC based N application. The Recommended dose of fertilizer applied to the experimental site was 150:50: 50 NPK kg/ ha and fertilizer applied as per the treatment.

The irrigation management treatments implemented with the plastic pipe of 40cm length and 100cm diameter. The tube was perforated with 2 mm holes on all sides leaving 15cm without perforation at one end. It was fitted to the treatment plots closure to the bund. The perforated portion of the tube 25 cm was inserted into soils leaving non-perforated 15cm length to be projected above the soil surface. This is called Field tube [3, 4]. The soil inside the tube was removed and provided with float device calibrated to measure the drop in the water directly by the mark of the float stick. As per the treatment schedule, the drop in water level below the ground surface was practiced. The quantum of water applied was measured with Parshall flume fitted in the feeding channels. The data collected from the field was analyzed statistically and the treatment variation was listed for significance by F test. For determination of critical differences at 5% level of significance, Fisher & Yates table were consulted.

## Results and Discussion

Effect of alternate wetting and drying irrigation regimes and nitrogen management practices on the growth contributing characters were presented in [Table-1].

### Effect of irrigation regimes and Nitrogen on growth attributing characters

The growth contributing characters were significantly affected due to the application of different irrigation regimes and nitrogen management practices [Table-1]. The growth characters Plant height (cm), LAI, Root length (cm), Dry matter production (kg/ha) and Total number of tillers / $m^2$ were recorded higher under SRI method of irrigation practice and was comparable with conventional practice of irrigation and AWDI at 10 cm drop of surface water. This is due to the favorable environment provided by different alternate wetting and drying regimes which allows for good aeration of the soil and more nutrient uptake, delayed senescence of the leaves and higher photosynthetic rate with increased plant height which resulted in increased growth attributes under SRI method of irrigation and AWDI at 10 cm drop of ground water table. Similar findings were reported by [5, 6].

In this study, the four equal split application of 100 % RDN fertilizer at basal, AT, PI and heading stages and LCC based N application proved to be the better method that reduce the losses and provide the optimum nutrient need for better growth and thus increased the plant height, root growth, LAI, and total tillers. The increase in growth characters was mainly due to the availability of nitrogen during the whole growth period of rice crop. Adequate and balanced supply of nitrogen invariably resulted in better uptake by rice resulting in improved vegetative growth, as indicated by taller plants, more number of tillers and leaves and increased leaf size leading to larger LAI. In the presence of adequate N and larger photosynthesizing surface, the dry matter accumulation proceeds at a rapid rate. As a result, DMP was greater under four equal split application of 100 % RDN fertilizer at basal, AT, PI and heading stages ($N_2$). Similar findings were reported by Shaiful Islam *et al*. [7]. The increase in this growth characters consequently resulted in better N uptake and good yield under this treatment.

Among all combinations, the SRI method of irrigation with four equal split applications of 100 % RDN fertilizer at basal, AT, PI and heading stages recorded higher growth attributes. This was due to better environment provided by SRI method of irrigation better source-sink conversion ascribed for higher productive tillers and more efficient use of N throughout the season, provided by four equal split application of N, resulted in higher growth characters under this combination. This was in agreement with findings of Vijayakumar *et al*., [8] and Sridevi and Chellamuthu [9].

**Table-1** *Plant growth attributes influenced to different Alternate wetting and drying irrigation regimes and Nitrogen management practices*

| Irrigation regimes | Plant height (cm) | Root length (cm) | LAI | Total number of tillers $m^{-2}$ | DMP (kg $ha^{-1}$) |
|---|---|---|---|---|---|
| $I_1$- CI practice | 90.65 | 26.86 | 5.50 | 474.3 | 12638 |
| $I_2$- AWDI at 10 cm drop of surface water | 88.16 | 24.64 | 5.16 | 468.3 | 12332 |
| $I_3$- AWDI at 15 cm drop of surface water | 85.63 | 23.50 | 4.98 | 431.2 | 11810 |
| $I_4$- AWDI at 20 cm drop of surface water | 78.31 | 22.69 | 4.44 | 379.3 | 10541 |
| $I_5$- SRI irrigation | 92.29 | 27.60 | 5.63 | 487.7 | 12954 |
| **SE d** | 0.76 | 0.38 | 0.14 | 8.6 | 177 |
| **CD (P=0.05)** | 1.77 | 0.87 | 0.32 | 19.8 | 408 |
| **Nitrogen Management Practices** | | | | | |
| **$N_1$-** 100 % RDN at Basal and PI stages | 82.82 | 23.44 | 4.66 | 419.9 | 11288 |
| **$N_2$-**100 % RDN at Basal, AT, PI and Heading stages | 90.96 | 26.75 | 5.44 | 491.0 | 12578 |
| **$N_3$-** 75 % RDN at AT, PI, and Heading stages. | 86.42 | 24.70 | 5.19 | 434.7 | 12051 |
| **$N_4$-** LCC based N application. | 87.82 | 25.34 | 5.27 | 447.0 | 12303 |
| **SE d** | 0.72 | 0.41 | 0.07 | 6.1 | 168 |
| **CD (P=0.05)** | 1.48 | 0.83 | 0.15 | 12.5 | 343 |
| **Interaction: I × N** | | | | | |
| **SE d** | 1.60 | 0.88 | 0.20 | 14.1 | 370 |
| **CD (P=0.05)** | 3.37 | NS | NS | 31.2 | 778 |

### Effect of irrigation regimes and Nitrogen management practices on yield attributing characters and yield of rice

The different yield attributing characters of rice studied were number of panicles $m^{-2}$, panicle length, number of grains $panicle^{-1}$, ill-filled grains percentage and test grain weight. Except ill-filled grains percentage, the above yield attributes, grain and straw yield were higher in SRI method of irrigation practice following the same trend as that of growth characters with AWDI at 10 cm drop of surface water and conventional practice of irrigation [Table-2]. Higher tiller production under SRI method of irrigation practice favoured greater conversion to productive tillers, due to the enhanced nutrient uptake and development of more floral and fruiting bodies *i.e.,* panicle with high productive components under this treatment was attributed to the capacity of the sink to receive the photosynthates from assimilating surface and store effectively under favourable soil plant water status [10]. The ill-filled grains percentage was lower with this treatment. The better aeration and profuse root system associated with optimum mobility and absorption of inorganic N increased the uptake of all other nutrients and contributed to favourable growth attributes which in turn had resulted with higher yield attributes. This is in agreement with findings of Senthil Kumar *et al.* [11] and Veeraputhiran *et al.* [12].

The four equal split application of 100 % RDN fertilizer at basal, AT, PI and heading stages registered increased yield attributes and yield and was on par with LCC based N application, which was due to higher uptake of N and might have synchronized with the crop demand and led to conductive translocation of more amount of carbohydrates to sink and consequently resulted on favourable growth which in turn reflected on producing increased yield attributes *viz*., productive tillers $m^{-2}$, panicle length, number of filled grains, lesser ill-filled grain percentage,

straw and grain yield. This was similar with findings of Sivakami [13] and Jayakumar [14]. As such a growth attributes SRI method of irrigation with four equal split applications of 100 % RDN fertilizer at basal, AT, PI and heading stages recorded higher yield and yield attributing characters.

**Table-2** *Plant yield attributes and yield influenced to different alternate wetting and drying irrigation regimes and Nitrogen management practices*

| Irrigation regimes | Productive tillers $m^{-2}$ | Panicle length (cm) | Filled grains | *ill-filled grain (%) | Straw Yield (kg/ha) | Grain Yield (kg/ha) |
|---|---|---|---|---|---|---|
| $I_1$- CI practice | 393.0 | 22.22 | 237 | 5.87 | 6607 | 5909 |
| $I_2$- AWDI at 10 cm drop of surface water | 383.4 | 21.69 | 233 | 6.39 | 6420 | 5769 |
| $I_3$- AWDI at 15 cm drop of surface water | 343.0 | 20.99 | 223 | 7.07 | 6155 | 5549 |
| $I_4$- AWDI at 20 cm drop of surface water | 298.1 | 19.69 | 208 | 9.70 | 5461 | 4942 |
| $I_5$- SRI irrigation | 400.8 | 22.72 | 246 | 5.16 | 6791 | 6060 |
| **SE d** | 8.2 | 0. 43 | 8.2 | - | 241 | 196 |
| **CD (P=0.05)** | 19.0 | 1.01 | 18.9 | - | 556 | 451 |
| **Nitrogen Management Practices** | | | | | | |
| **$N_1$-** 100 % RDN at Basal and PI stages | 336.0 | 20.10 | 210 | 8.89 | 5820 | 5297 |
| **$N_2$-**100 % RDN at Basal, AT, PI and Heading stages | 405.3 | 22.80 | 247 | 5.31 | 6588 | 5880 |
| **$N_3$-** 75 % RDN at AT, PI, and Heading stages. | 351.7 | 21.17 | 227 | 6.77 | 6324 | 5651 |
| **$N_4$-** LCC based N application. | 361.7 | 21.78 | 235 | 6.38 | 6414 | 5755 |
| **SE d** | 5.3 | 0.52 | 5.3 | - | 108 | 86 |
| **CD (P=0.05)** | 10.8 | 1.06 | 10.79 | - | 221 | 175 |
| **Interaction: I × N** | | | | | | |
| **SE d** | 13.1 | 1.09 | 13.13 | - | 320 | 256 |
| **CD (P=0.05)** | 28.2 | NS | NS | - | 741 | 563 |

*Data statistically not analyzed

**Consumptive Water Use and Water Use Efficiency under the irrigation treatments:**

The consumptive water use and Water use efficiency of crop for various irrigation treatments is presented in [Table-3]. The amount of water required meeting the demands of evapotranspiration and metabolic activities of rice together constitute the consumptive water use, which includes the effective rainfall during the growing season. As such, the conventional practice of irrigation *i.e.*, 5 cm depth of irrigation one day after the disappearance of previously ponded water consumed more water of 1083 mm. This was followed by SRI method of irrigation practice, which registered the next higher consumptive water use of 1009 mm. Practicing AWDI with 10, 15 and 20 cm drop of ground water table were recorded least water consumption of 986, 882 and 845 mm respectively.

In the case of water use efficiency the AWDI at 15 cm drop of water table recorded higher and followed by SRI method of irrigation practice. AWDI at 10 cm drop of water table and AWDI at 20 cm drop of water table, which also recorded moreover efficiently.

**Table-3** *Effect of irrigation regimes on water use and water use efficiency (kg $ha^{-1}$ $mm^{-1}$)*

| Irrigation regimes | Consumptive water use (mm) | water use efficiency (kg $ha^{-1}$ $mm^{-1}$) |
|---|---|---|
| **$I_1$-** CI practice | 1083 | **5.46** |
| **$I_2$-** AWDI at 10 cm | 986 | **5.85** |
| **$I_3$-** AWDI at 15 cm | 882 | **6.29** |
| **$I_4$-** AWDI at 20 cm | 845 | **5.84** |
| **$I_5$-** SRI irrigation | 1009 | **6.01** |

*Data statistically not analyzed

**Conclusion**

In this experiment, it was confirm that, Alternate Wetting and Drying Irrigation has the potential to minimize the consumptive use in rice cultivation and also maintaining good agronomic performance and better yield. Among the treatments SRI method of irrigation practice and four equal split application of 100 % RDN fertilizer at basal, AT, PI and heading stages performed as best treatments.

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**Author Contributions:**

[1]. Kannan V, Ph.D. Scholar in the Dept. of Agronomy, AC & RI, Madurai. He has doing research work in stress management of cotton.

[2]. Sundersingh Rajapandian J, Professor, guide of this research project. He has 37 years of research and teaching experience. He had handled more than 20 Project Schemes under TNAU and AICRP.

[3]. Srinivasn G, Scientist who gave valuable suggestions for the research work. He has specialized in weed management and Cotton.

**Abbreviations:**

AT- Active tillering, AWDI: Alternate Wetting and Drying Irrigation, CI: Conventional Irrigation, cm- centimeter, DMP: Dry matter production, $K_2O$: Potassium, kg/ha/mm: Kilogram per hectare per millimeter, kg/ha: Kilogram per hectare, LCC- Leaf colour chart, LAI- Leaf area index, mm: Millimeter, N: Nitrogen, $P_2O_5$: Phosphorus, PI- Panicle Initiation, RDN: Recommended dose of Nitrogen

**Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.

**Conflict of Interest:** None declared

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